Wideband Data Error Rates

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Data on the error and outage characteristics of the Ground Communications Facility's wideband data circuits have been gathered and analyzed. Most error blocks occur one at a time, whereas missing blocks are grouped into strings (outages) having a median length of about 10 blocks.

Most ground communications digital transmission channels are subject to two problems – they cause bit errors and they occasionally fail, generating outages. Over the years the Ground Communications Facility (GCF) has measured and analyzed these impediments in the high-speed data and wideband data transmission circuits (see Refs. 1-6).

The GCF digital transmission circuits have changed greatly since they were first used by the DSN. Originally, all overseas circuits were derived from HF radio, with a slow transition to underseas cables in the late 1960s. Most of the overseas (and some domestic) circuits are now routed via commercial communications satellites. Circuit quality has continuously improved.

In early 1977, it was realized that measurement of the current wideband impediments would be needed in order to design an efficient wideband error control system. Accordingly, the GCF developed a measurement and analysis configuration in the Central Communications Terminal in JPL Building 230. This configuration is illustrated in Fig. 1.

The configuration utilized two status outputs from the subsystem's Coded Multiplexer:

(1) Data Block Detected: This lead carries a pulse each time the Coded Multiplexer recognizes a data block. Lack of such a pulse implies a missing block.

(2) Block Error Detected: This lead pulses only when a recognized block contains an error.

The two status leads were electrically isolated from their other loads and connected to external interrupt inputs of a MODCOMP II minicomputer (the future EDC 4, to be exact). A real-time program processed the pulses using time, block size, and circuit bit rate to determine the sequence of good, error, and missing blocks. These sequences were recorded on disc.

The configuration was used by GCF Operations to record approximately 200 passes of Viking Telemetry (2400 bit block size). Some of the "passes" were very short, some were not properly terminated, some contained inappropriate rates, etc. These faulty passes were deleted during off-line editing of the data.

The resulting edited tape contained usable data from 143 tracking passes – a total of about 1290 hours (54 days) of real-time wideband data. The data was about equally divided between the three 64-m DSSs (14, 43, and 63). It was

considered a good random sample of inbound wideband circuit operation.

The raw data on the tape consisted of counts of consecutive good, error, or missing blocks, along with the time when the sequence ended. As an example:

Time	Good	Error	Missing
083215	4395	–	–
083215	–	2	–
083216	–	–	13
083226	105	–	–

This sequence shows that 4395 good blocks were received, followed by 2 blocks each containing bit errors, then 13 missing blocks (an outage), then 105 more good blocks, etc. No attempt was made to tell where the error(s) occurred in a block nor the causes of the error or missing blocks.

The first analysis program basically consisted of a dump of the taped data. Visual inspection showed that most of the DSS 43 errors were systematic – every $690 \times N$ blocks there was one block in error. N ranged from one to five. Since DSS 43 was using a line rate of 27.6 kbps and a 2400-bit block, the 690 figure translated to exactly 1 minute. NASCOM (the NASA agency which provides circuits to the GCF) was advised of the problem. They determined that timing signals were not being properly synchronized within their network. Several months were spent remedying the situation. DSS 43's data was then clean until the very end of the recording period, when the same problem reoccurred.

The second analysis program omitted the 21 DSS 43 passes which contained systematic errors. The balance of the passes were processed to yield the data shown in Table 1.

In all cases the block missing rate in Table 1 is much larger than the block error rate. This correlates with earlier measurements of HSD and WBD performance. The combined error and missing rate, 0.00280, represents approximately 1.75 min of outage/error per average (10.5 h) tracking pass. Unfortunately, these 1.75 min are widely scattered through the pass, occurring, typically, only a few blocks at a time. The error plus missing block rate runs considerably higher for the overseas stations, averaging 149 blocks per hour for all stations.

An event, as used herein, is a single set of like blocks. For example, 4395 good blocks followed by 2 error blocks, 13 missing blocks and 105 good blocks represent 2 good events, 1 error event and 1 missing event. As shown in Table 1, the event rates are also much higher for the overseas DSSs, and average 9.9 per hour throughout the net. Paraphrasing, there is an average of 9.9 "gaps" in each hour's worth of wideband data. Each such gap is a subject for recall after the pass.

Figure 2 shows the distribution of the lengths of the error and missing events for all of the stations. As an example of how to read the curves, there were approximately 440 error events which contained four to seven consecutive error blocks. There were 107 missing events containing 64 to 127 consecutive missing blocks.

Examination of these curves and their data shows:

(1) Most error events contained only a single block in error. (Actually, 78% have only a single block in error.)

(2) Long strings of error blocks just don't occur. (The longest error event was 28 blocks long.)

(3) Consecutive missing blocks (missing events) can be quite long. The longest in this set of tests was, in fact, 9083 blocks, about 13.2 min.

(4) The median length of the missing events is around 10 blocks; i.e., the typical outage is about 10 blocks long.

(5) An error correction scheme which could span a 1000 block error/outage period would probably correct more than 99% of the gaps.

Various algorithms for wideband error correction are being modeled against the actual test data. Results of these studies will be presented in a future report.

References

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Table 1. Wideband data performance statistics

Parameter	Station			Total
	14	43	63	
Number of passes	46	25	48	119
Tracking hours	611	230	431	1272
Block error rate	0.000095	0.000470	0.000553	0.000319
Block missing rate	0.000693	0.003772	0.004313	0.002484
Combined rate	0.000788	0.004241	0.004866	0.002800
Error + missing rate, blocks/hour	58 blks/h	174 blks/h	212 blks/h	149 blks/h
Error events	1715	3234	6488	11437
Missing events	210	296	607	1113
Error + missing rate, events per hour	3.15 Ev/h	15.3 Ev/h	16.5 Ev/h	9.9 Ev/h
Max consecutive error blocks	11	28	22	28
Max consecutive missing blocks	5530	3635	9083	9083

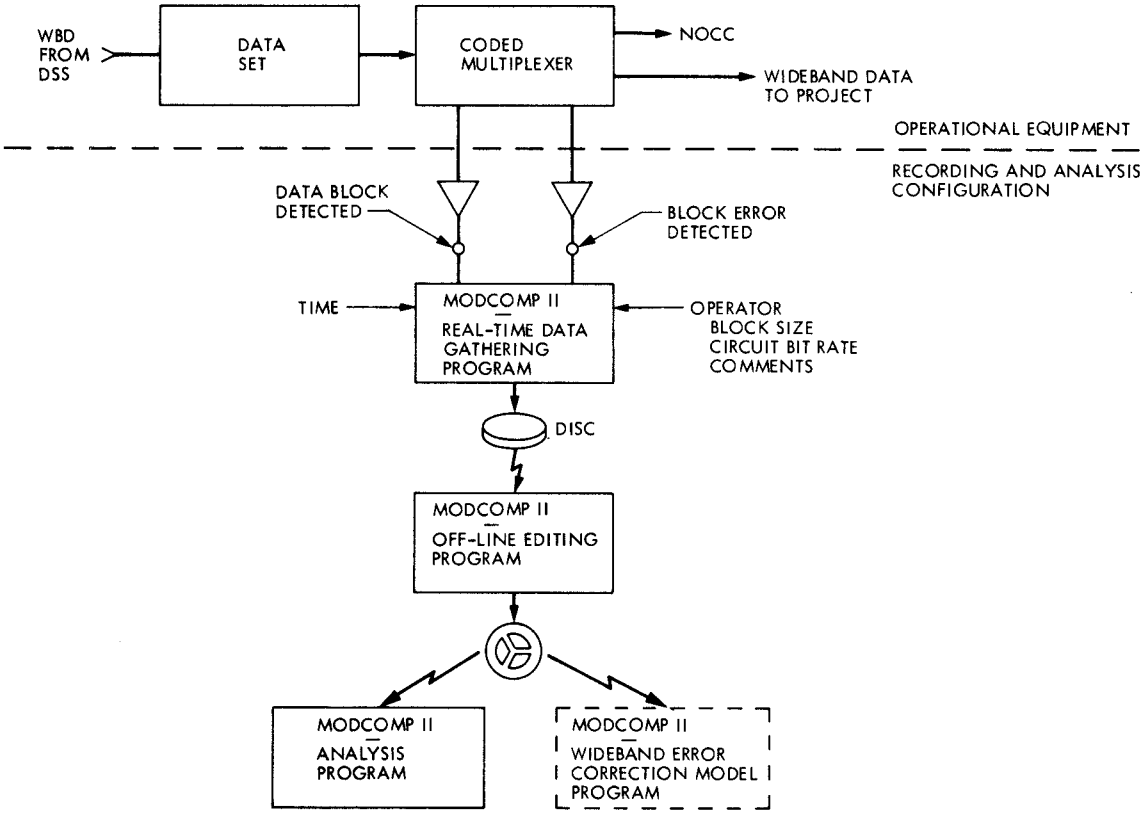

Fig. 1. Recording and analysis configuration

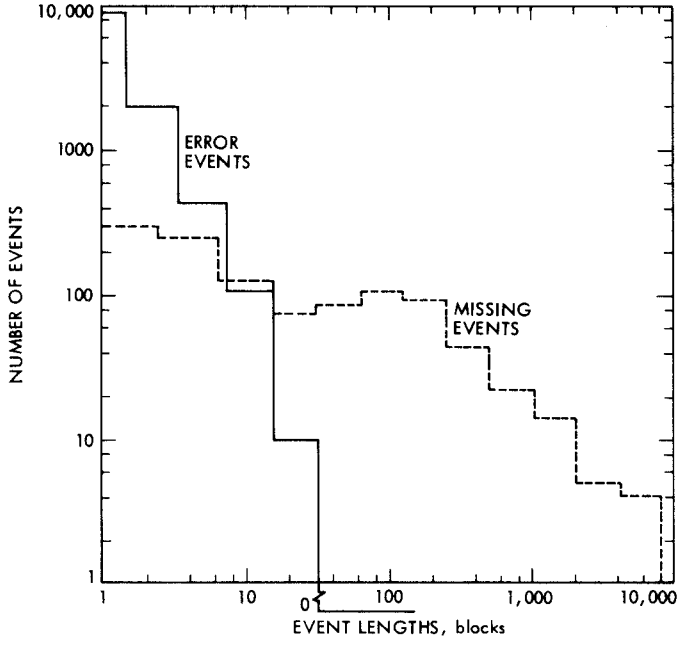

Fig. 2. Distribution of error and missing event lengths (all stations)